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Does climate change information affect stated risks of pine beetle impacts on forests? An application of the exchangeability method

Simone Cerroni [a,b,*], W. Douglass Shaw [c]

[a] Department of Economics, University of Trento, Via Inama 5, 38122 Trento, Italy
[b] Fondazione Eni Enrico Mattei, Corso Magenta 63, 20123 Milano, Italy
[c] Department of Agricultural Economics and Hazard Reduction and Recovery Center, Texas A&M University, College Station, TX 77843-2124, USA

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ABSTRACT

Risks are an essential feature of future climate change impacts. We explore whether knowledge that climate change might be the source of increasing pine beetle impacts on public or private forests affects stated risk estimates of damage, elicited using the exchangeability method. We find that across subjects the difference between public and private forest status does not influence stated risks, but the group told that global warming is the cause of pine beetle damage has significantly higher risk perceptions than the group not given this information.

1. Introduction

In a recent paper, Bulte et al. (2005) consider the role that outrage and moral responsibility have in the determination of maximum willingness to pay (WTP) to reduce negative environmental outcomes, using a field experiment. They find that the WTP to protect seals relates to the nature or cause of the threat to the seals. Similarly, here we are interested in knowing whether the nature of the threat to forests matters, not in the determination of an individual's WTP, but in the formation of risk perceptions of forest damage. In particular, we want to understand whether explicitly framing climate change as the source of the pine beetle infestation affects laypersons' perceptions.

We use laboratory experiments to explore whether specifically stating the essential cause of an environmental outcome matters in eliciting subjective environmental risks. The cause of interest is global warming and the risky outcome we consider is future pine beetle destruction of private or public forests. Climate change may increase the destructive capability of the pine beetle, which attacks pine forests in several places in the United States, including the state of Texas. Given scientific controversy about risks related to climate change, public support for mitigation and adaptation policies for the forestry sector can be strongly influenced by laypeople's assessments or perceptions about those risks (Leiserowitz, 2005).

The International Panel on Climate Change (IPCC) uses the word "risk" to characterize a possible range of outcomes related to climate change, and these risks themselves may be uncertain. In particular, risk is a combination of probability of an event and the severity of the event, given that it occurs. Knowing the probability is essential if an economist wishes to use the common economic framework to assess risky choices or options, which is the expected utility model (EU).

Even the most basic element of climate change, the average temperature that may occur at a particular date, is typically described using a range, rather than a point estimate. Competing models of global circulation assign different probabilities to these ranges, as well as other outcomes such as sea level rise. If the experts in the science community cannot pinpoint estimates of the probabilities that characterize the risks of climate change, then the public might be expected to form their own opinions about them. Perhaps this is why some individuals in the public seem certain that global warming is already happening, and others seem certain it is not and never will (e.g., Bostrom et al., 1994; Leiserowitz, 2005, 2006; Weber, 2006).

If subjective probabilities can be formulated, then the subjective expected utility framework (SEU) can be substituted for the EU framework. However, we note that the SEU framework most often assumes that individuals collapse their uncertainty into a degenerate expected value, thus ultimately being a risk framework and not one of uncertainties (Riddel, 2011 makes this point). All of this makes it

* Corresponding author at: Department of Economics, University of Trento, Via Inama 5, 38122 Trento, Italy. Tel.: +39 02 52036963; fax: +39 02 52036946.
E-mail addresses: simone.cerroni@unitn.it (S. Cerroni), wdshaw@tamu.edu (W.D. Shaw).

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of great interest to ascertain subjective estimates of risk in the case of global warming impacts.

Our main application here relates to an approach to risk elicitation. Methods for uncovering subjective probability estimates vary from the most simple approach one could imagine (just ask – i.e. see Jakus et al., 2009; or Nguyen et al., 2010) to more complicated approaches, such as the one we use here, called the exchangeability method (EM). While risk elicitation is common in decision analysis, particularly for studies of financial risk and uncertainty economics, it is much less used in the context of environmental and resource economics. Probability or risk elicitation here should not be confused with elicitation of risk preferences, wherein some method is used to determine an individual's level of aversion to risk, which is most often related to decisions involving tradeoffs and financial outcomes. Risk preference studies do not directly allow recovery of the individual's estimate of the probability of an outcome, though coefficients of risk aversion can be recovered from the data and used to estimate EU models that correspond to particular functional forms of risk aversion, such as the popular Constant Absolute Risk Aversion (CARA) form.

Much like elicitation of values, a risk elicitation mechanism guarantees reliable risk estimates if it provides subjects with some type of an incentive to state their real beliefs or preferences (e.g., see Vossler and Evans, 2009). Despite many kinds of incentives that may accomplish this, many economists take the view that only monetary incentives can succeed in ensuring incentive compatibility. This discussion has largely been in the domain of experimental economics, conducted in the laboratory. For example, the probability scoring method has been implemented as an incentive compatible approach to eliciting probabilities, when the gambles can be easily played out. Again, these are typically going to involve simple financial lotteries or gambles (see Savage, 1971; Karni, 2009). However, many economic studies, as well as laboratory studies in psychology, involve hypothetical choices or scenarios, as ours does here (see Manski, 2004).

The problem in the context here is one that will nearly always be encountered when the outcomes are large scale environmental outcomes, or health outcomes, for the simple reason that these cannot be played out in the laboratory. In part to address this issue, Fiore et al. (2009) set up a virtual reality experiment involving forest fires, which are a clear-cut example of something that cannot be played out in the laboratory. The outcomes are instead played out in the virtual world, which is supposed to more closely mimic the real world than simple pictures or verbal text. Subjects see the fire using virtual reality devices, but of course cannot feel the heat, nor do they actually own property that may be destroyed by the forest fire. Fiore et al. (2009) do not attempt to elicit individual's perceptions of forest fire risks, assuming instead that the probabilities that reveal risk attitudes relate to money gambles. We are not willing to concede that risk attitudes for money will carry over to risk attitudes for other outcomes in every situation.

A lot of research, much in the psychology literature, has demonstrated that risk or probabilities are very difficult for the layperson to understand and recommend different approaches for communicating risks to people and then eliciting their best estimate (e.g., see Corso et al., 2001; Gigerenzer and Hoffrage, 1995; Hammitt and Graham, 1999). Just asking a person to state what they believe a probability is can be fraught with difficulty. Even when the best available estimates from scientists are presented as information, individuals who are asked seem to ignore this information, or form opinions that might be orders of magnitude away from the science (e.g., see Riddel and Shaw, 2006). Hence, in this paper we implement a rediscovered, but quite old method of eliciting probabilities, the EM. The EM relies on the definition of exchangeable events as formulated by de Finetti in 1937. To our knowledge, though recently rediscovered by Baillon (2008) and Abdellaoui et al. (2011), this approach has not yet been used for eliciting environmental risk perceptions in empirical studies.

Using the EM, our subjects are not directly asked to state forest damage probability estimates. Instead, as will be explained below, our subjects are asked a series of choice questions that essentially reveal points on each subject's cumulative density function (CDF), where the probability relates to whether the forests will be damaged by the pine beetle. Using the exchangeability method we hope to avoid the usual problem of subjects' understanding of probabilities, especially small ones (see Manski, 2004). As researchers we indirectly infer the probability subjects attach to those outcomes, which is possible because of the solid statistical theoretical foundation for the EM (Chew and Sagi, 2006). Using this EM framework, our main hypothesis is that stated or elicited risk estimates may be influenced by the underlying cause of pest damage.

The remainder of the paper is as follows. After very briefly reviewing the literature on elicitation of environmental risk, we explain the exchangeability method of risk elicitation and describe the way that our experimental study was implemented. Results for pine beetle risk estimates are presented and discussed in the final sections. Our tests of the consistency of responses provide some support for the notion that subjects answer questions reliably.

2. Perceptions and policy implications

The IPCC provides a good deal of scientific evidence that climate change will change forest ecosystems all around the world. Note that in colder regions, forest ecosystems may gain from climate change because both temperature and precipitation will slightly increase, but in warmer regions, forests may be negatively impacted by this same trend because of desertification: conditions will become too hot and dry. In currently dry or arid regions, the risk of further droughts may reduce forest net ecosystem productivity (NEP) and increase the risks of wildfires and insect pests (IPCC, 2007).

Specific impacts differ in different regions of the planet, but this trend is likely for the state of Texas, where scientists predict that higher temperatures and lower precipitation will increase the chance of southern pine beetle outbreaks or attacks. This insect already threatens pine forests in many other states, including Alabama and Georgia. In Texas, most of the pine forests are in the east part of the state, where they cover an area of around 12 million acres. From 1970 to 1996, the annual average volume of timber killed in Texas by southern pine beetles was almost 184,000 m^3 for a value of about $ 120 million (Gan, 2004).

Policies to protect forests from further pine beetle destruction are possible, but need public support, and in Texas, as in most states within the United States, that translates to support of the state government. Given the high degree of uncertainty related to science-based estimates of climate-change risks, decision makers, including government officials, often make decisions according to their subjective estimates of those risks rather than on scientific predictions (Norris and Kramer, 1990). As an example, Pingali and Carlson (1985) have shown that fruit farmers' demand for different pest management strategies strongly depend on their perceptions of the damages to the orchards. More recently, Pregernig (2002) found that forest owners' choices to engage in restoration measures also rely on subjective perceptions of the urgency of the problem.

Perceptions relate to willingness to support public investments in environmental protection, and if either the public, or the government, or both, fail to believe something is a serious problem, then no resources will be forthcoming for that protection. For example, Viscusi and Zeckhauser (2006) showed that Americans who have higher perceptions of future temperature increases are willing to pay more for policies which address global warming. The perception or belief problem may also be an issue in the case of Texas forest owners who need to plan and implement forest management controls to avert the risk of pine beetle infestation in the future, or state government officials involved in funding such programs.